

# The impact of EUV mask residual-type defect thickness on wafer printability

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## Summary

- ◆ The residual-type bridge defects were fabricated by etching full-height defects using EB etching tool.
- ◆ The residual-type defects were printed on wafer.
  - The 2.9 and 8.2-nm-high TaBN layer cause 30 and 40 percent of reflectance reduction respectively.
  - No printable ML damage was observed around EB etching process area.
  - At outer focus range, the 2.9-nm-high bridge defects causes more than 10 percent of CD error.

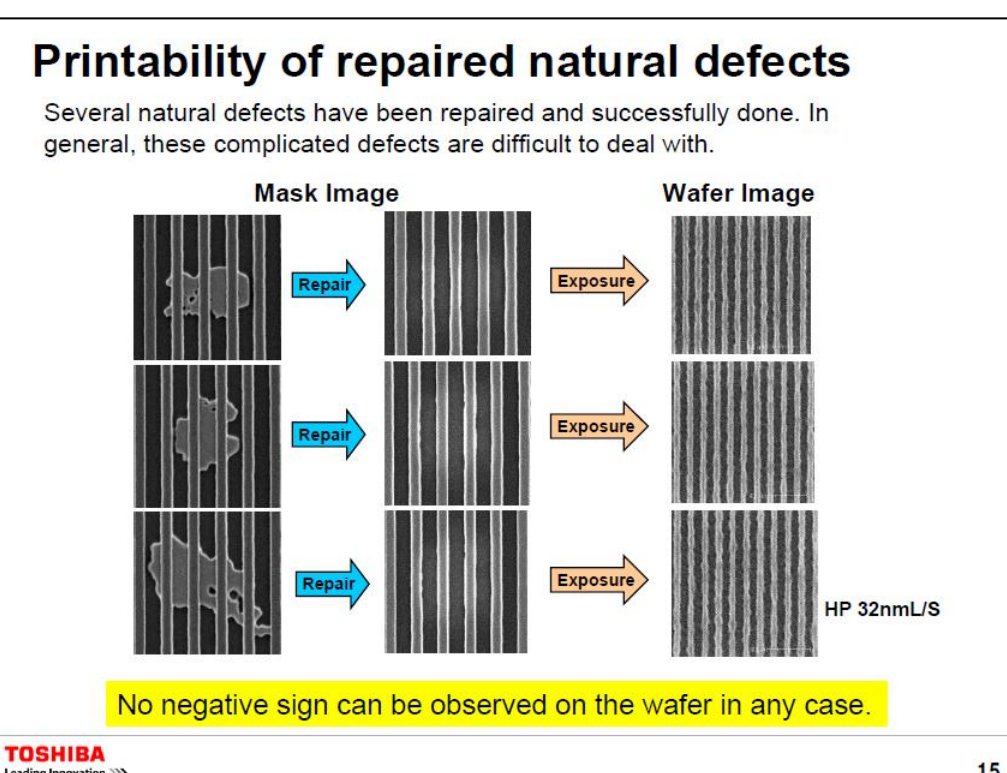
## Introduction

The impact of residual-type defects is not clear while the impact on wafer printing by EUV mask pattern defects with various shapes has been already investigated using programmed defect masks.

This presentation describes the experimental results by wafer printing using Small Field Exposure Tool and computer simulation results. In addition the fabrication method of programmed residual-type mask defects is also described.

### Motivation

Example of real residual-type defect



Source: M. Itoh, "EUV Mask Readiness in 2012", 2011 EUVL symposium

EUVL mask requirements (ITRS 2011 edition)

Year of Production	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
DRAM 1/2 pitch (nm)	32	28	25	23	20	18	16	14	13	11
Flash 1/2 pitch (nm)	20	18	17	15	14	13	12	11	10	8.9
MPU ASIC Metal 1 (M1) 1/2 pitch (nm)	32	27	24	21	19	17	15	13	12	11
Mask minimum primary feature size (nm)	88	78	70	62	55	49	44	39	35	31
Defect size (nm)	25	23	20	18	16	14	13	11	10	9

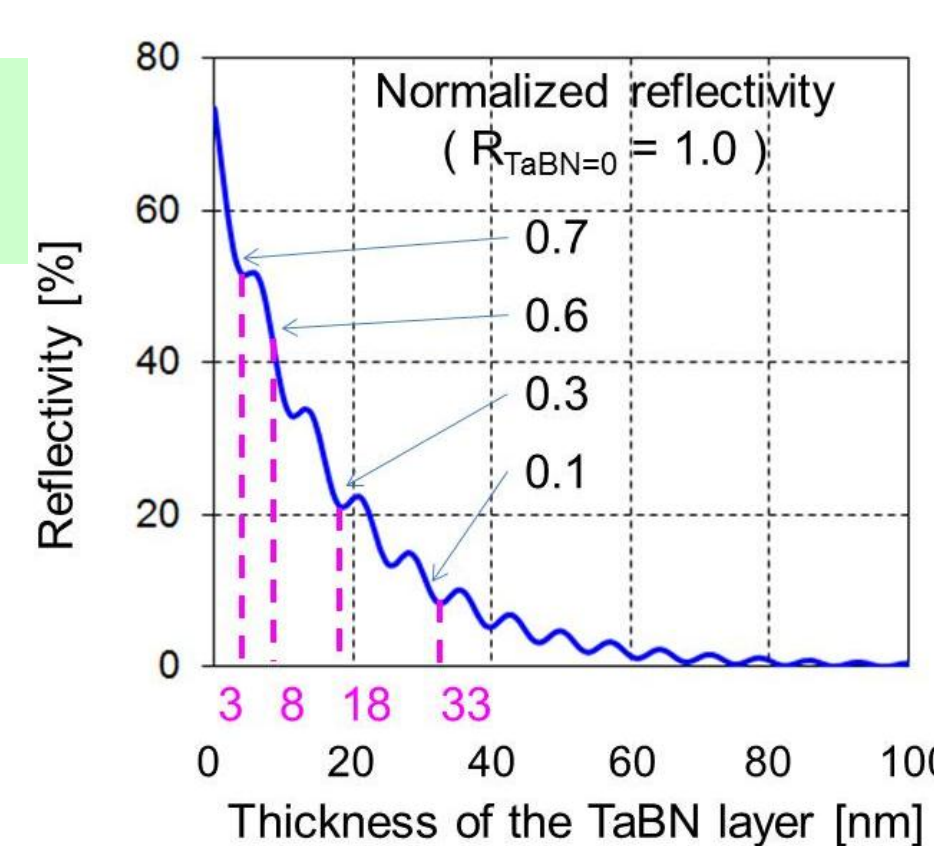
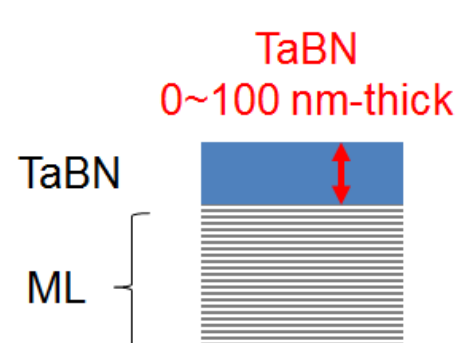
- ✓ Definition of defect size in the ITRS is only "Square root of the X-Y plane area of the defect". However, the residual-type defect also seems to be categorized as printable defect.

### Defect thickness target

TaBN thickness vs EUV reflectivity

Simulator: EM-Suite™

Calculated mask model



- ✓ Target height of the residual-type defects were set to 3, 8, 18 and 33 nm for printability test, because the variation in the reflectivity caused by thickness error of TaBN happens to be small.

### Preparation of the residual-type programmed defect

Mask pattern: hp 225 nm L/S  
Defect height control: MeRiT HR32

Original defect (900 x 225 nm, 66-nm-high)

Fully etched defect (0-nm-high)

Height of the residual-type defect: 33.1 nm, 17.8 nm, 8.2 nm, 2.9 nm

SEM images

Absorber

ML

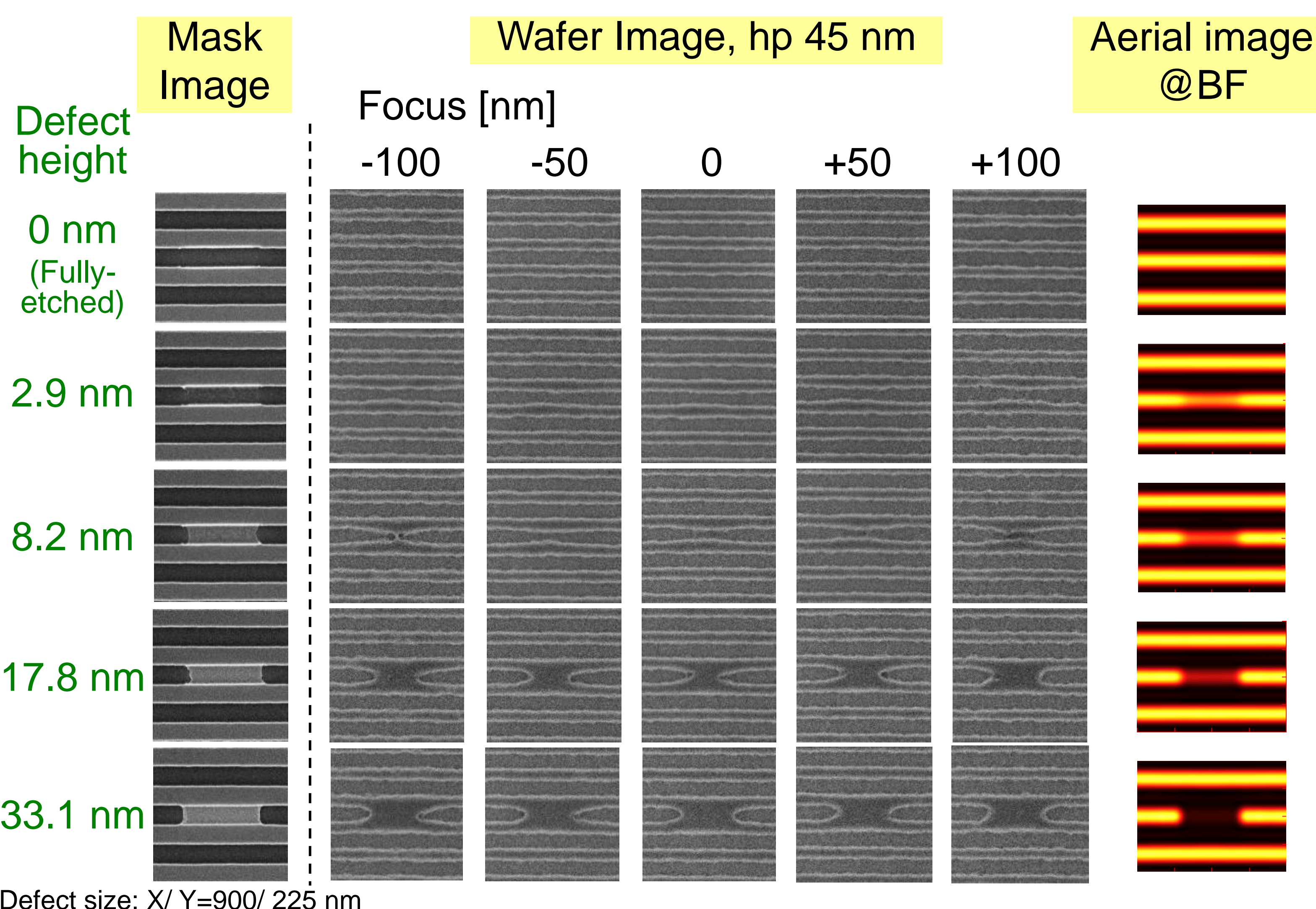
Defect

AFM images

- ✓ The residual-type defects were well fabricated without ML damage.

## Wafer printability of the residual-type defects

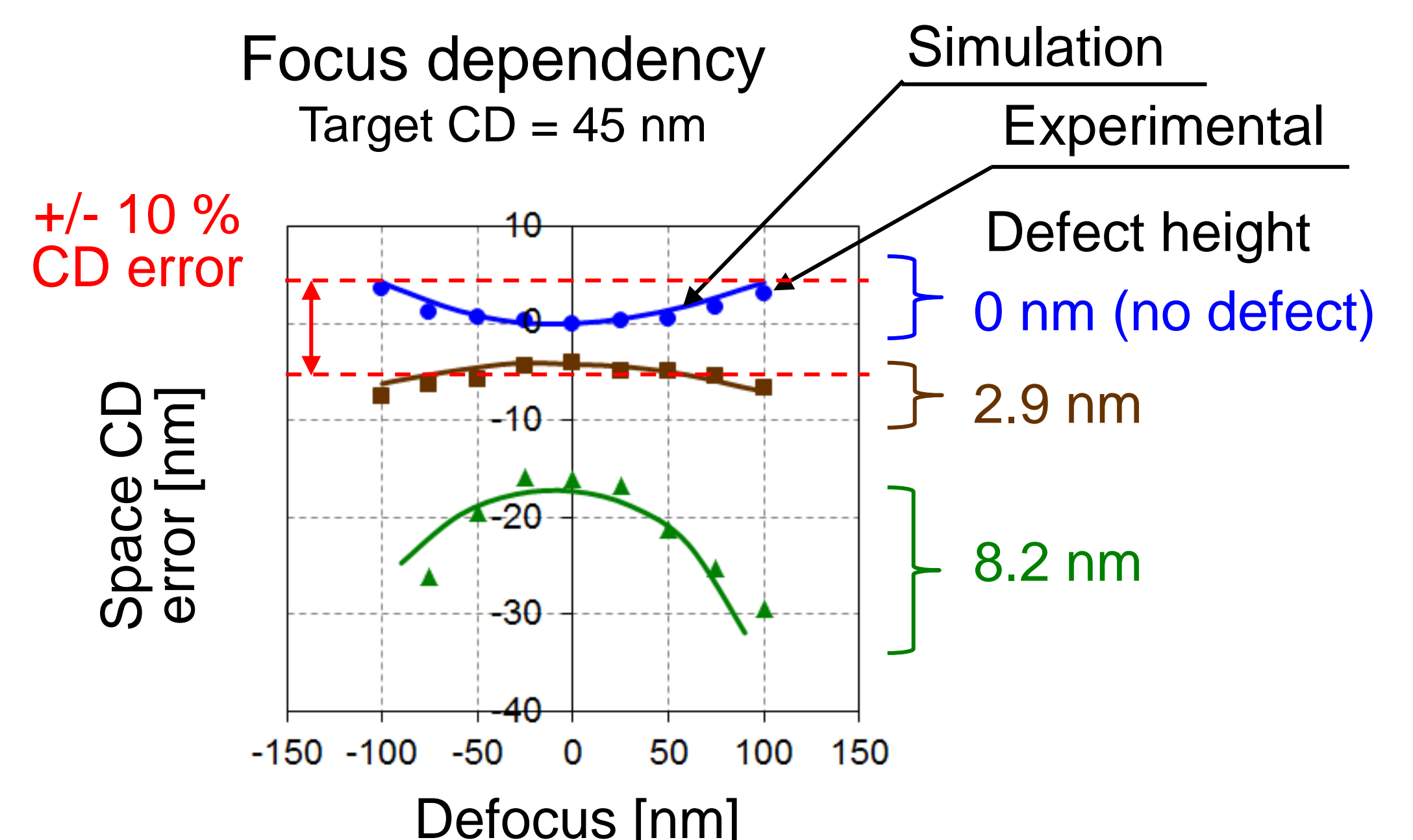
Printing tool: SFET (NA: 0.3, sigma (inner/outer): 0.3/ 0.7, Mag.: 1/5)



Defect size: X/ Y=900/ 225 nm

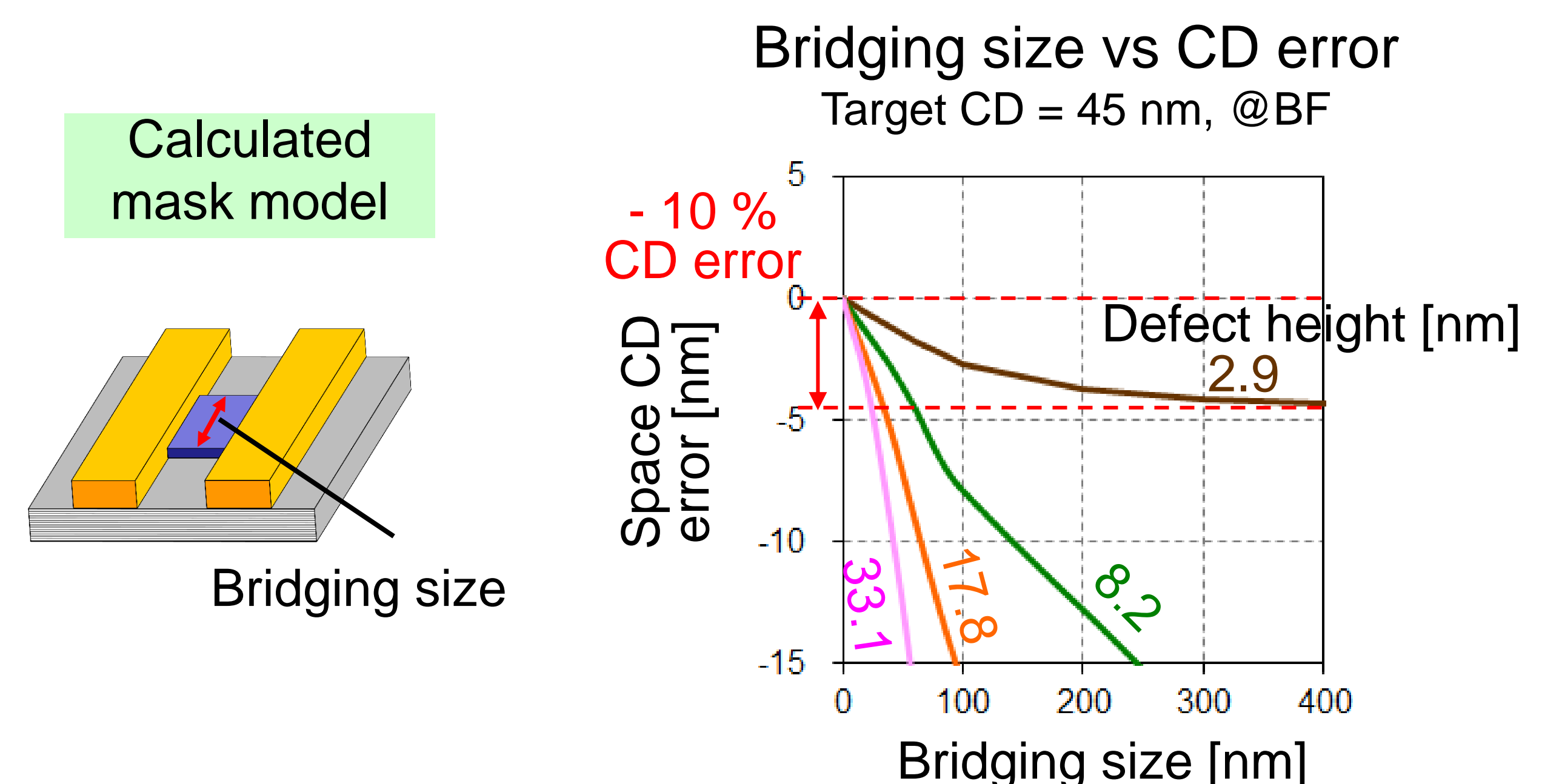
- ✓ The full etched defect was not printed on the wafer within +/- 100 nm focus range.
- ✓ The residual-type defects are apparently printed on wafer even if its height is only 8.2 nm.
- ✓ The calculated images show 2.9-nm-thick residual-type defect causes intensity loss of EUV light.

## Measured and calculated CDs



- ✓ The 2.9-nm-high residual-type bridge defect causes more than 10 % of CD error at outer focus range.

## Bridging size dependency



- ✓ The residual-type bridging defects will cause strict CD degradation, and should be repaired after detected by inspection tool.

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